PROGRESS REPORTS
FROM
EXPERIMENT STATIONS

SEASON 1956-57

ADEN PROTECTORATE

PUBLISHED BY
THE EMPIRE COTTON GROWING CORPORATION.
12 CHANTREY HOUSE, ECCLESTON STREET,
LONDON S.W.1.

1957

COMMONWEALTH MYCOLOGICAL INSTITUTE
6 SEP 1957

PROGRESS REPORTS FROM EXPERIMENT STATIONS

The reports for the seasons up to and including 1950-51 were published in seasonal volumes; the following are still in print and available at 3/- per volume post free.

1923-25 (one volume), 1926-1927, 1931-32, 1934-35.
1935-36, 1942-43 and 1945-46 to 1950-51.

From 1951-52 the reports from each territory were published individually each season. A few of the 1951-52 reports are out of print, but all others are available post free at 1/- per report or 7/6d. for the seasonal set.

ADEN PROTECTORATE
RESEARCH SECTION, EL KOD
PROGRESS REPORT FOR THE SEASON 1956-57

BY

K. R. M. ANTHONY and J. E. A. OGBORN

Planting Dates.	*Picking Dates.*	*Close Season.*
Mid August-mid October.	January-May.	June-mid August.

Introduction

Staff

The Officer-in-charge, Mr. R. R. Anson, left in June 1956, on retirement. Mr. Anson was in the service of the Empire Cotton Growing Corporation from 1925 until 1951, when he came to Aden from the Sudan, where he was Chief Cotton Breeder. He was responsible for the pioneer research work in the Aden Protectorate, and the present high reputation of Aden cotton is due largely to his work. In his last year in Aden he organised the establishment of the Research Section. His duties have been taken over by Mr. K. R. M. Anthony.

Dr. N. R. Fraser resigned for health reasons in February 1957. The post of Entomologist is now vacant.

Visitors

Dr. Herbert Greene, Adviser on Tropical Soils to the Secretary of State for the Colonies, visited the station in November to advise on irrigation and soil deterioration investigations.

Dr. G. M. Wickens visited Abyan in December in order to examine the cotton root rot (wilt) problem. He has kindly arranged for the plant pathology section, Namulonge, to undertake further investigations during next season. A note by Dr. Wickens on Abyan root rot of cotton is included in this report.

Mr. J. C. May spent the last ten days of an East African tour at the station for discussions on research and cotton production.

Research Headquarters

As funds became available further progress was made in equipping the laboratories. With re-routing of sea traffic around the Cape the interval between ordering and final delivery of equipment in Aden became even longer and more uncertain. A serious deficiency is lack of meteorological equipment, the arrival of which is still awaited.

The planting of tree species around the laboratory block and staff quarters continued. This section is the only organisation for plant introduction in south Arabia and an effort is being made to build up a fairly comprehensive collection of useful and ornamental species.

Crop Prospects

Rainfall in the coastal strip of the Protectorate was scanty during 1956 and a total of less than an inch of rain was recorded at Khormaksar Airport, Aden. In Abyan the bulk of the precipitation during the period under review fell between September 28 and 30 (2-3 in.). Rainfall for the rest of the cotton cropping season was negligible.

Floods in the Wadis Bana and Hassan are consequent upon rainfall in the mountainous country on both sides of the Protectorate—Yemen border. In Abyan, apart from a heavy flood in early August, floods were generally late and resulted in a high percentage of late sowing. A total of 127·7 million cubic metres of water was recorded at the headworks of the Wadi Bana for 1956. During August and September, the recommended period of irrigation for cotton, 69·7 million cubic metres (17·2 thousand acre metres) reached the headworks. However a record flood was received in early October, which not only watered some areas a second time and destroyed young crops but also watered new areas, most of which were sown to cotton. As a result cotton planting continued longer than was desirable or recommended.

A total of 24,000 effective acres was sown to cotton in Abyan. Owing to the praiseworthy efforts of the Board's Inspectorate, the programme of controlled light watering of scheduled areas was achieved fairly satisfactorily, and in the El Fana area a drop of approximately 5 ft. in the water table was recorded compared with a similar period in 1955-56. On the negative side it must be noted that the standard of crop husbandry was deplorable and many farmers appeared to consider only two operations necessary, sowing and picking. This probably reflects the absence of any tradition of farming in the Abyan delta and too easy returns in the first few years. Amongst malpractices can be listed: inadequate or no presowing cultivation, failure to weed, delay in commencing picking, failure to pick cleanly, mixing of pickings and an inadequate clean up. Excessive weed growth, mainly *Desmostachya bipinnata* (L.) Stapf. in the south and *Cynodon dactylon* Pers. in the north, with consequent heavy competition for available soil moisture, led to early flushing and a rapid tail-off in the crop. To this must be added the effect of Sudan bollworm, which was widespread in the Delta. The Abyan crop is not expected to exceed 14,000 bales of 400 lb., bulking in grade 4.

In contrast, Lahej, the second largest producer, is expected to yield 10,000 bales from 8,000 effective acres. Last season an average

grade of 3·5 was obtained, compared with 3·9 in Abyan. The proportion of grades in the Lahej crop will probably be similar this season. The state has an established farming tradition and the standard of cultivation was satisfactory. The best of the outside areas was Yeramis (1,000 acres), where the crop should average 1·3 bales per acre and bulk between grades 2 and 3.

Outside areas will probably bring the total output for the Protectorate up to 28-29,000 bales.

Cotton Pests

Circumstances prevented the completion of the planned entomological research programme.

In Abyan there was a further increase in the incidence of Sudan bollworm, which could be found throughout the delta and now ranks as a serious pest. Attacks from American bollworm were localised and severe only in one area south of El Kod. In this instance the attack was at least partly compensated by a second crop of bolls.

Damage from Egyptian bollworm was recorded as severe only in Meifa, a small cotton growing area west of Mukalla, where *Abutilon* sp. appears to be an important alternate host. In this area pink bollworm appeared towards the end of picking for the second season in succession.

Some staining of cotton in Abyan may be attributed to *Oxycarenus* spp. Other pest damage was not serious. It is noteworthy that the incidence of cotton pests in Lahej, now in its third year as a cotton producer, is still light.

Plant Breeding

Selection and Propagation

Progeny rows of BAR XL1 and AB3 were planted with controls of the parental material, emphasis in selection being laid on length and regularity of the staple. Twenty-five selected progenies will form the next bulk and go forward to testing plots next season.

A 3·77 acres nucleus bulking area of BAR XL1 at El Kod averaged 1,690 lb. seed cotton per acre, with a ginning outturn of 36·1, and will provide sufficient seed for the first commercial bulking area at Um Gibla next season. Two hundred acres of BAR XL1 at Um Gibla this season should provide enough seed for Yeramis and Giar in 1957-58. Seed for the rest of the area will be drawn from the top grades of AB3 grown at Yeramis and Giar and will replace AB1 throughout the Protectorate. During the coming season it is hoped that it will also be possible to establish an effective separate bulking system for Lahej, in view of the rapid expansion of cotton growing in the state.

The station is fortunate in having full control of all cotton propagation and seed issues.

Other Varieties

Domains Sakel, BLR 14/16, BAR 14/25 and Wilds Early were again included in the breeding plots. A propagation plot of Karnak has provided further material for testing.

Cotton Variety Trial

Ten varieties were planted on September 5 in a Latin square layout at Giar farm. Plot size was 40 sq.m. harvested. The spacing was 1 m. × 1 m., except for the two American varieties, which were planted 1 m. × 50 cm. Thinning took place to three plants per planting point. Mean yield data are given in Table 1.

TABLE 1.

ABYAN COTTON VARIETY TRIAL, 1956-57

	% G.O.T.	*Seed cotton yields*		*Corresponding lint yields*	
		lb. per acre	*% of control*	*lb. per acre*	*% of control*
BAR XL1	35·9	1945	99	698	100
AB Control	35·5	1963	100	697	100
BAR 12/3	32·1	2075	106	666	96
Wilds Early	34·9	1906	97	665	96
AB3	35·6	1825	93	649	93
BAR XL3	35·7	1818	92	649	93
AB1	35·6	1762	90	627	90
Karnak	35·7	1531	78	546	78
Domains Sakel	33·0	1606	82	530	76
BAR 14/25	32·7	1607	82	525	75
S.E.				41	
Sig. response 5%				115	
1%				154	

Results are in conformity with the previous trials (1952-56). Of the varieties under trial, Karnak and Sakel types are the least suitable for Abyan conditions. Their yield performance over the five years of testing has been inferior to that of the X1730 types and is combined with a high susceptibility to root rot. With high winds they again lodged badly. The Sudan-Egyptian L types seem to be best suited for cotton growing in the Protectorate.

Abyan Root Rot of Cotton (Wilt)

The fourth backcross of Wilds Early × 1730A hybrids was made to L cotton (BAR XL1). Lacking a technique for the transference of root rot, hybrids were planted (September 15) in a field at Giar, where it was known that 23 per cent of all planting points had been infected in the previous season.

Selections were made last season from second backcross lines on the basis of their resemblance to X1730A (L) or Wilds Early (W) types, giving nine L and nine W third backcross lines. These were planted with nine Wilds Early and eighteen BAR XL1 controls of parental bulk material, the latter being in a majority to facilitate spread of the disease. Each line comprised 60 plants. Mortality as a result of root rot first occurred in the second half of October and Table 2 indicates the spread of the disease thereafter. Little mortality occurred after the end of December.

TABLE 2.

PLANT MORTALITY DUE TO ROOT ROT
(Running plant total)

Date	*Oct. 29*	*Nov. 7*	*Nov. 21*	*Dec. 11*	*Dec. 24*	*Jan. 9*	*% Total*
BAR XL1 (A)	2	7	21	77	88	94	17
BAR XL (B)	7	11	22	79	85	91	17
Hybrids (L)	8	9	12	36	46	51	9
Hybrids (W)	4	10	15	28	35	40	7
Wilds Early	1	2	2	10	18	23	4

Fourteen plants selected from hybrid lines last season, on the basis of vegetative resemblance to the L parent, were planted in progeny rows for selfing. Two per cent root rot was recorded in the population. Amongst 12 F_1 lines (X1730 × Wilds Early), one per cent mortality occurred.

The rest of the field was sown to lubia (*Dolichos lablab* L.), which completely succumbed to the disease.

Outcrossing

An experiment was laid down to evaluate the order of outcrossing to be expected at Giar farm, using the red *arboreum* gene of BAR 5/6 as a marker.

AGRONOMY

Soil Fertility

Owing to lack of control of the cultivators no effective crop rotation has yet been established in the Abyan delta. In some areas of Abyan cotton has been grown successively on the same land since the beginning of the scheme. This practice has led to reduced vegetative growth of the cotton plant, a decline in yield and, in conjunction with other factors, of grade.

A rotation experiment was laid down this season on a site of low fertility comparing two, three and four course rotations with cotton as 50, 33 and 25 per cent of the cultivable area. Rotations are: (1)

cotton-sorghum, (2) cotton-sorghum-lubia, (3) cotton-sorghum-lubia-fallow. All phases of each rotation are included in each of five blocks.

Anticipating the possibility that nitrogenous fertilisers may prove economic, cotton and sorghum phases are split for application and non-application of nitrogen in the form of ammonium sulphate. Split plots were 80 sq.m. harvested. Fertiliser was applied at a rate equivalent to 10 grm. nitrogen per planting point for cotton, spaced 1 m. × 1 m., and 5 grm. per planting point for sorghum, spaced 1 m. × 50 cm. Crops were sown on September 11.

Table 3.
Rotation Experiment, Giar
Mean yield nitrogen treatments (lb. per acre)

Nitrogen grm. per p.p.	*Seed cotton*	*Sorghum straw*
0	751	10,800
10 and 5	1,137	11,790
S.E.	± 90	± 765
Sig. response 1%	379	

Cotton gave a response of 51 per cent to nitrogen. This result is in conformity with last season's preliminary results and with observations which suggest that a considerable area of Abyan would respond to nitrogen application. Unfortunately, the depredations of Ruppell's weaver birds severely reduced the sorghum grain crop, and rendered results invalid. Yields of straw were high and exhibited no significant difference between treatments.

An important consideration in the economics of fertiliser application is the form used, with particular reference to transport costs. Thus, with cost per unit nitrogen and crop response equal, a nitrogenous fertiliser with high nitrogen content has obvious merits.

An experiment was carried out on cotton at Giar farm to test four forms of nitrogenous fertiliser. These were applied at two dates and two rates, 5 and 10 grm. nitrogen per planting point. A 4 × 2 × 2 layout with four blocks of eight plots was used, the third factor interaction being confounded with blocks. One plot receiving no nitrogen was included in each block. Plots were 20 sq.m. harvested. In this experiment the forms used were urea (46·7 per cent N), calcium nitrate (11·9 per cent N), ammonium sulphate (21·3 per cent N) and aqueous ammonia. Cotton was planted on September 15 at standard spacing, 1 m. × 1 m., thinned to 3 plants per planting point. Late arrival of fertilisers delayed the early application until October 20. The second application was on November 18. This late delivery also necessitated the substitution of aqueous ammonia for a proposed ammonium nitrate treatment. Summarised mean yield data are presented in Table 4.

TABLE 4.

TYPES OF NITROGEN EXPERIMENT, GIAR

(lb. seed cotton per acre)

Mean, no nitrogen: 1,485

	Nitrogen grm. per p.p.		*Date application*		
	5	*10*	*Oct. 20*	*Nov. 18*	*Mean*
Urea	1572	1788	1863	1497	1680
Calcium nitrate	1431	2029	1777	1683	1730
Ammonium sulphate	1751	2026	2246	1531	1889
Ammonia	1682	1800	1835	1647	1741
Mean	1609	1911	1930	1590	

S.E. nitrogen and date mean ± 122. S.E. types mean ± 172.
Sig. response 5% 366. 517.

Field observations indicated a pronounced response to the double dressing of nitrogen and to the earlier application. In common with all trials at Giar this experiment had a high coefficient of variation (27·7 per cent). None of the treatment differences reached significance, but it seems probable that the responses to double rate and early application over control are real.

A problem in fertiliser application in this area is the paucity and unpredictability of rainfall, and the gradual drying out of the surface soil as the cropping season advances. Thus the earliest possible time of application would appear to be advantageous. In this and the other experiments the fertiliser dressings were applied one foot away from the plants and six inches deep. With double rates a single application was placed on opposite sides of the plant. It is envisaged that for farmers the southern Arabian bull plough could be adapted for drilling fertiliser at sowing.

The use of fertilisers forms an essential part of the attempt to assess experimentally the limiting factors to plant growth. An NPK experiment was carried out at the new El Kod farm on land known not to have been cultivated within the last two years, and only infrequently in the past, in order to assess the fertility status of this soil type. A standard 3^3 layout was utilised, with a single replicate in three blocks, the second order interaction confounded. Plot size was 20 sq.m. Cotton was planted on August 26 at standard spacing, and the fertilisers were placed on September 19. Nitrogen was applied as ammonium sulphate, phosphate as granular triple superphosphate and potash as potassium sulphate. The rates of application were equivalent to 0, 5 and 10 grm. of the main element per planting point.

A summary of the main effects and interactions is given in Table 5.

TABLE 5

NPK EXPERIMENT, EL KOD

Mean yield 1,707 lb. seed cotton per acre

Factor	*L*	*C*	*Factor*	
N	− 97	+ 59	N′ P′	+ 9
P	− 98	+ 97	N′ K′	+91
K	−125	0	P′ K′	+ 7
S.E.	± 64	±110		±78

The land proved to be in good heart and the vegetative growth of the crop was enormous. Nevertheless, yields of seed cotton were high and in contrast with many of the nearby farms, where lack of weeding and competition from *Desmostachya bipinnata* resulted in stunted growth. There were no significant responses. A satisfactory feature of the experiment was the comparatively low coefficient of variation (7·9 per cent).

The cropping capacity of land irrigated from flood water is maintained to some degree by deposits of silt. Indeed the main agricultural soils of the Protectorate are alluvial in origin and fields become gradually built up by successive layers of silt. These deposits are thus of some importance and work has been initiated to assess the value of silt deposited from normal irrigation.

A preliminary experiment was carried out to compare cotton irrigated from silt laden flood and silt free ground water, respectively. Salt was added to the flood water to equalise its content with the ground water and water was measured on to plots to ensure a uniform irrigation of 50 cm. Superimposed on these treatments were two rates of nitrogen at two dates of placement. Nitrogen, as ammonium sulphate, was applied at 5 and 10 grm. per planting point, on October 15 and November 18. A 2^3 layout was adopted with three replications. Two plots not receiving nitrogen were included in each block; one received silt and the other did not. The previous season's cropping was cowpeas. Cotton was planted on September 13 but the initial germination was poor and led to a high degree of plant irregularity. The mean yields for silt and nitrogen treatments are summarised in Table 6.

TABLE 6

SILT EXPERIMENT, GIAR.

(lb. seed cotton per acre)

Mean, no nitrogen no silt: 1,059

Mean, no nitrogen plus silt: 1,094

Nitrogen grm. per p.p.	*No silt*	*Silt*	*Mean*
5	1,077	999	1,038
10	1,273	1,114	1,194
Mean	1,175	1,057	
S.E. Means			± 173

The flood water contained an average of 1·47 per cent silt by weight. Plots irrigated from this source received the total silt content, equivalent to approximately 29 tons per acre. No positive response was recorded to silt and plots will be planted with sesame next season to follow any residual effects in the second year. Neither was there a significant response to nitrogen.

The amount of irrigation water applied to land is important, not only because of its direct relationship with plant growth but also as a factor in soil deterioration. In connection with the latter investigations it is essential to know the water duty required by cotton and the main food crops under local conditions. An experiment was therefore laid down comparing three rates of irrigation for cotton, 33·3 cm., 66·6 cm. and 100 cm. respectively. Because of the probable relationship between amount of irrigation water and response to nitrogen, three rates and three forms of nitrogen were included. They were 0, 5 and 10 grm. of nitrogen per planting point as urea, calcium nitrate and ammonium sulphate. A 3^3 layout with single replicate was used, the second order interaction being confounded. Plot size was 20 sq.m. harvested. The site chosen was a clay to clay loam overlying fine sand, with a water table at approximately 16 feet, and had been dry fallow for at least three years. Cotton was planted on September 25 at standard spacing.

Signs of water strain, with flagging of leaves at midday, were apparent in December-January but a plot score indicated that this effect was due to position rather than treatment.

The two way table of rates of irrigation and amounts of nitrogen is given (Table 7). The only conclusion that can be drawn is that the lowest level of irrigation, 33·3 cm., was adequate to produce a satisfactory yield. This is in conformity with results of measurements at Giar farm (Table 10) and forms a basis for future work. In further investigations the relationship between availability of water and grade will also have to be considered.

TABLE 7

COTTON WATER DUTY EXPERIMENT, EL KOD
(lb. seed cotton per acre)

Nitrogen grm. per p.p.	*Water duty cm.*			*Mean*
	33·3	66·6	100	
0	1,754	1,315	1,773	1,614
5	1,321	1,947	1,220	1,496
10	1,626	1,335	912	1,298
Mean	1,567	1,539	1,301	

S.E. Water duty and nitrogen means = ± 76. Sig. response 5% = 248.
S.E. Interaction = ±132. Sig. response 5% = 430.

Cotton Spacing

Cotton planting in Abyan is performed by a primitive but effective bull planter. A spacing of one metre between lines is advocated but, in practice, spacing may vary 50 per cent either way within the same field. As it is considered time to review recommendations a series of spacing distance experiments is being initiated.

A preliminary experiment was carried out comparing cotton planted at 33·3 cm., 66·6 cm. and 100 cm. in rows one metre apart, and thinned to one, two and three plants per planting point. The layout was in the form of a 3^2 factorial experiment with four replications, plot size 50 sq.m. harvested. Cotton was planted September 9, following sorghum in the previous season.

Results are presented in Table 8. Heavy rains at the end of September washed out part of one block, which was replanted. As a result of this, and a site of obviously patchy fertility, growth was irregular. Thus observations indicated that the yields of the three lowest means are in a considerable measure attributable to chance. Allowing for these discrepancies, the high level of fertility favoured three plants per planting point at the widest spacing.

TABLE 8

COTTON SPACING EXPERIMENT, GIAR
(lb. seed cotton per acre)

Within row spacing (cm.)	*No. plants per planting point*			*Mean*
	1	*2*	*3*	
33·3	1,717	1,842	1,934	1,831
66·6	1,390	1,457	2,142	1,663
100	1,818	1,063	2,172	1,684
Mean	1,642	1,454	2,082	

S.E. Spacing and thinning means ± 179. Sig. response 5% = 522.

Other Crops

Introductions have been made of a number of sorghum and sesame varieties from the Sudan. These were sown in observation plots and propagated for further testing.

Amongst tree species, an important introduction has been a collection of *Eucalyptus* spp. from Australia. These have now been planted out and a number of species have shown good early growth.

It is pleasing to record the formation of a market gardeners' co-operative society in the Fadhli State, under the auspices of the Co-operative and Marketing Department. As noted in last season's report, there are considerable possibilities for the development of market gardening in Abyan. It is hoped that current work at the station on crop water requirements will provide a basis for advice on the better utilization of ground water resources.

Soil Science

Soil Survey

On the advice of Dr. H. Greene, a detailed survey was made of an area of 50 acres of salt marsh at El Fana using special equipment originally developed by him. Thirty borings through very difficult soil were made to depths of up to eight metres. No deep impermeable layers were discovered, though some bores were stopped by shingle or gravel beds at a depth of five metres. All the bores passed through an apparently continuous band of coarse sand, which started at about 3 metres depth. It is proposed that the high lateral conductivity of this layer should be utilised to drain the marsh by tapping it at the lowest part of the marsh. The area is being examined by the Abyan Board for a suitable line for a drain.

A survey of a proposed irrigation site in the Wadi Idm (Hadhramaut) has been reported on separately.

Infiltration Survey

Using a very simple apparatus, a large number of infiltration rate readings have been collected. There is considerable variation between readings both within the boundaries of fields and between the fields. The mass of data still awaits statistical analysis. The main factors affecting rate of infiltration are undoubtedly soil texture and moisture content. The following data show this quite clearly. The results are quoted for the infiltration of 10 cm.

Table 9

Sample area	*No. of readings*	*Area covered*	*Mean*	*Remarks*
(a) Bagidar Farm	8	18 acres	15·6 cm/hr.	Fine sand to silt. Air dry.
(b) Kod Farm	12	14 acres	7·1 cm/hr.	Silty clay loam to clay loam. Air dry and cracked.
(c) Giar Farm	19	36 acres	3·0 cm/hr.	Silty clay loam. 10% W/W soil moisture.
(d) El Fana marsh	25	50 acres	1·1 cm/hr.	Silty loam. Salt marsh at or just below field capacity.

(a) illustrates the waste of water occasioned by irrigating unsuitable land of insufficient storage capacity. The mean figure to date for infiltration readings taken between Giar and Batais is 3·34 cm. (b) and (c) though absorbing different amounts of water would in fact end with approximately the same depth of profile at field capacity in the same time. (d) the low mean figure obtained is mainly due to the permanently saturated soil profile, but is also probably partly a result of some alkaline deterioration. This is characteristic of this type of salt marsh.

Water Requirement in Abyan

The most fundamental agricultural operation in arid areas is the application of irrigation water. Information as to the amount of water required to maintain a crop of cotton has been obtained from three different sources:

(a) Direct field experiments.

(b) Local practice.

(c) Meteorological data.

(a) The single field experiment so far performed in Abyan indicates that an above average crop of cotton can be grown by using as little as 33 cm. of water on a soil profile which was practically air-dry before irrigation.

(b) Direct measurements of the amount of water applied by farmers indicate that as little as 10 cm. is often applied to fields in areas of high water-table. A series of infiltration measurements were carried out on Research Section fields during watering in August 1956, and the quantity of irrigation water applied calculated. A summary of these data with final yields of seed cotton is presented in Table 10. Good crop growth and high yields were obtained from very low water duties. This was consequent upon a comparatively high initial soil moisture content (10% W.W.). The water table averaged between 15 and 18 feet depth.

TABLE 10

Field	*Hours watered*	*Duty (cm.)*	*Yield lb. seed cotton per acre*
13	3·00	6·6	1274
19	4·51	12·0	1654
6	6·38	18·9	750
11	5·20	18·9	1485
20	5·75	19·8	1945
18	8·04	25·7	2172

(c) Meteorological data are not yet available for the Abyan area, owing to the delayed arrival of equipment. Figures for Khormaksar, thirty-five miles away, indicate that the maximum possible transpiration and evaporation during the growing period of the cotton is of the order of 70 cm. Abyan is commonly alleged to be somewhat cooler and more humid than Khormaksar. This implies that its evaporation and transpiration can be assumed to be less.

The above information, although preliminary, indicates that the water duty required for cotton is much less than was originally supposed. A reserve of soil moisture as a result of previous irrigations and a rising water table have contributed to reduce the application rates required in the older irrigated areas. It is clear, therefore, that a recommendation for cotton of 50 cm. maximum and 33 cm. minimum water duty is more than adequate in these areas. Sorghum and sesame will almost certainly require less because they occupy the land for a shorter time.

Allowing for the unavoidable wastage in canals it is therefore tentatively suggested that one acre/metre of water at the headworks should be sufficient to water an area of the order of two acres under conditions of maximum water economy.

ABYAN ROOT ROT OF COTTON

BY

G. M. WICKENS

(Cotton Research Station, Namulonge, Uganda)

Previous reports from Aden Protectorate have referred to a disease of cotton variably called wilt (*Rhizoctonia*), wilt (*Rhizoctonia solani*), and wilt (*Rhizoctonia* and *Fusarium vasinfectum*). The cause has however never been satisfactorily identified (Anson, personal communication), and this fact, together with the reported increasing

incidence of the disease, led to my making a brief visit to the affected areas of the Abyan Scheme in December 1956. This note sets on record my observations during this visit, and some opinions arising therefrom.

The disease is characteristically a root rot. In order to avoid misconception, through confusion with other known diseases of cotton of both vascular wilt and root-rotting types, this disease should be known for the present simply as "Abyan root rot". The record of *Fusarium vasinfectum* (*F. oxysporum* f. *vasinfectum*) as being implicated is improbable and should be discounted. One or more species of *Rhizoctonia* may possibly be implicated, but there is as yet no proof of this.

The disease occurs sporadically, in roughly circular patches commonly up to 10 yards in diameter and sometimes more, in which all plants are killed. The onset of disease in individual plants is extremely rapid. On one day a plant may appear perfectly healthy; on the next all its leaves may be withered or dead. It tends to reappear on sites of its occurrence in the previous season, with further extensions.

Symptoms in the roots of affected plants are striking. The outer layer of the cortex of the tap root, and sometimes of the laterals also, is papery and separated from the inner cortex, which has a shredded appearance, consisting of long separate longitudinal fibres. In plants recently collapsed these symptoms extend into the base of the stem; in plants still apparently healthy, at the edges of affected sites, these symptoms may be found in the lower parts of tap roots, but have not yet reached the region of emergence of the main laterals. It seems a reasonable inference that infection occurs deep in the soil, and that rapid upward movement of cortical disintegration of the tap roots leads, as it passes the laterals, to the characteristic rapid leaf collapse. Discolouration of the cortex and outer layers of the xylem of affected roots and stem bases is variable; either vivid yellow, or carmine, or reddish brown or brown.

These symptoms, and the general behaviour of the disease, agree closely with the description by Saccas of a disease of cotton in the Tchad district of French Equatorial Africa (La flétrissure des cotonniers du Tchad. Coton et Fibres Tropicales, 9, 1, 1954). The Tchad disease was attributed by him to a primitive fungus named by him *Olpidiaster gossypii*. This claim was however based solely on his microscopic observation of the fungus in diseased tissues and its isolation on a special medium. The generally accepted requirements of inducement of disease by inoculation, and re-isolation of the pathogen, were not recorded as having been attempted or fulfilled.

The symptoms and behaviour agree closely also with those described for a widespread and destructive root rot of cotton in West Pakistan

(to which Saccas made no reference). Vasudeva (Studies on the root rot disease of cotton in the Punjab—1. Symptoms, incidence and cause of the disease. Ind. Journ. Agric. Sci., 5, 1935) on the basis of results of inoculations with fungi isolated from diseased roots, ascribed the disease to a strain of *Rhizoctonia solani* and to ? *Rhizoctonia bataticola* (*Macrophomina phaseoli*). Later work, such as that by Inamullah Khan (Some studies on root rot disease of cotton in Pakistan. Pakistan Cotton Bulletin, Annual Number 1954), has failed to demonstrate that these fungi are pathogenic to cotton "under normal soil conditions". Here also conclusive proof of the cause of the disease seems to be lacking.

A very similar disease was seen in a number of other crops grown in the Abyan scheme. Lubia (*Dolichos lablab*), pigeon pea, velvet beans, simsim, mung beans and castor oil all showed rather similar symptoms in dead and dying patches, although the vivid colouration of diseased tissues commonly seen in infected cotton was generally absent.

The Abyan Scheme is thus faced with a destructive cotton disease of unknown cause. It has the appearance of being due to a parasitic organism (or organisms), possibly catholic in host range, that is highly virulent under certain, perhaps rather critical, soil conditions. It may be that the present ascending phase will be halted by natural controlling factors, or it may be that the apparent high resistance found in the American variety Wilds Early, if successfully transferred to the L types, will constitute a safeguard against any possibly calamitous further extension. But all this is conjecture, and there is no firm ground for optimism. There is urgent need of study, which can be made satisfactorily only on the spot, to establish the cause and to determine factors governing incidence. Essential facilities are being provided for this work, which will be undertaken by Mr. Logan of the plant pathology section, Namulonge, during next season.

Publications

Anthony, K. R. M. and Willimott, S. G.—"A Study of Soil Fertility in Zandeland". Empire Journal of Experimental Agriculture, 1956. Vol. 24, pp. 75-88.

Anthony, K. R. M.—"Cotton Production in Aden Protectorate". Empire Cotton Growing Review, 1957. Vol. 34, pp. 1-5.

Anthony, K. R. M. and Willimott, S. G.—"Cotton Interplanting Experiments in the South West Sudan". Empire Journal of Experimental Agriculture, 1957. Vol. 25, pp. 29-36.

Appendix

Key to Symbols Used in the Report

AB Control	Rogued material from X1730A, imported from Sudan.
AB1	Bulked selections from Sudan-Egyptian X1730A.
AB3	Second bulk filter of AB1.
BAR XL1	An importation from Sudan. First filter of BAR 1730L.
BAR XL3	An importation from Sudan. Third filter of BAR 1730L.
Domains Sakel	Domains Sakel, imported from Sudan.
Karnak	An importation from Egypt.
Wilds Early	American long staple type imported from Sudan.
BAR 12/3	An importation from Sudan. Fifth backcross BP52 carrying B_2.
BAR 14/25	A Sakel type from Sudan carrying B_2 and B_3, formerly known as BLR 14/25.

Received May 1957.

Printed by T. Buncle & Co. Ltd., Arbroath.